Docket No. 2003-072-TAP

MULTIPLE HEADS FOR MAGNETIC MEDIA STORAGE APPLICATIONS

BACKGROUND OF THE INVENTION

1. Related Applications:

This Application for Patent is related by subject matter to commonly assigned U.S. Patent Numbers 6,101,059; 5,850,328; 5,293,285; and co-pending U.S. Patent Application Serial Number 10/394,876, Attorney Docket Number 2002-123-TAP, filed on March 21, 2003; and U.S. Patent Application Serial Number 10/163,988, Attorney Docket Number 2002-007-TAP, filed on June 5, 2002; each of which is incorporated herein by reference.

2. Field of the Invention:

The present invention relates generally to reading and writing data in high track density, flexible media storage applications, and more specifically, but not exclusively, to a plurality of read/write heads for reading and writing data on magnetic tape.

3. Background of the Invention:

A read/write head is a device that reads and writes data from and to a magnetic tape. The surface of the tape is moved past the read/write head. The data is written using a write head. The write head contains a write coil wound around a highly permeable magnetic core consisting of write poles separated by a small gap ("write gap"). When current is passed through the coil, the movement of the current produces a magnetic field

turn, magnetizes the magnetic recording media as it passes the write gap. By switching the polarity of the current in the coil, data can be stored in the media as regions of opposite magnetization polarity recorded in the magnetic recording media. The regions of recorded opposite magnetization polarity correspond to stored data bits (e.g., 1's and 0's), which are detected by a read sensor as the recorded media is passed back over the read/write head. A read/write head for high track density tape typically reads or writes multiple data channels simultaneously.

Figure 1 depicts a pictorial representation of a conventional read/write head arrangement for a magnetic tape drive. For clarity, only a pertinent section **100** of a conventional magnetic tape drive is shown. Tape drive section **100** includes a magnetic tape **102**. For example, magnetic tape **102** can be wound on a supply reel (not shown) that is rotatably mounted within a magnetic tape cartridge (not shown). Thus, magnetic tape **102** can be moved by the magnetic tape drive in a horizontal direction, as indicated by the horizontally oriented arrow in **Figure 1**. As shown, magnetic tape **102** includes four groups or bands of tracks **104a-104d**. However, in general, conventional magnetic tapes can also include more or less than four bands.

A typical magnetic tape (e.g., **102**) consists of a Mylar substrate on which has been deposited a recording surface. The recording surface consists of a layer of magnetic material. As shown in **Figure 1**, the recording surface can be subdivided into a plurality of bands

(e.g., **104a-104d**), each band containing a plurality of data tracks.

Tape drive section **100** also includes a movable read/write head assembly **106** positioned between tape guides (not shown). Read/write head assembly **106** includes a read/write head **108**, which reads and writes data from and to magnetic tape **102**. For example, a coarse and fine position actuator (not shown) moves read/write head assembly **106** in a vertical direction (as indicated by the vertically oriented arrow in **Figure 1**), and positions read/write head **108** over one of the bands **104a-104d** for reading and writing data from and to the magnetic media in that band (e.g., **104a**) on a plurality of tracks. In order to read/write data from/to all of the bands **104a-104d**, the read/write head position actuator must sequentially position the read/write head **108** over each band **104a-104d**. Consequently, a major drawback of the conventional read/write head assemblies is that they require both coarse and fine positioning actuators and control for each read/write band on the magnetic tape.

In conventional magnetic tape data recording systems, the read/write data rate or data throughput can be increased in a number of ways. For example, the conventional recording systems can increase the read/write data rate by increasing the speed of the tape moving past the read/write head, the linear density of the bits stored on the tape, or the number of parallel data channels placed in the head. However, these conventional solutions are limited significantly by the

magnetic and physical characteristics of the storage media being used, technical obstacles in the fabrication of conventional tape drives and heads, and limits with respect to the ingenuity of the conventional designs.

Furthermore, increasing the number of parallel data channels on a recording head places a significant demand on existing head fabrication technologies. For example, increasing the number of data channels per recording head makes the head more cumbersome because of a corresponding increase in the size and stiffness of the "flex" cable involved (cable containing conductors for carrying read bias and write currents from/to the read/write head). Also, the number of data channels per recording head is limited by the stability of the storage media used, which dictates the span and number of read/write structures that can be placed side-by-side on the head. In other words, the stability of the storage media determines just how closely spaced the magnetic (read/write) structures can be on a head and still provide acceptable yield and crosstalk values.

In this regard, by requiring more space between the magnetic read/write structures on a head, the head is required to move substantially longer distances over the storage media relative to the small width or pitch of the bands, in order to reference the entire width of the media and read or write all of the data therein. As discussed above, conventional tape drives have heads that require both coarse and fine actuators for positioning control. Thus, in order to improve data throughput in magnetic media recording systems, at a minimum, these

obstacles to cost-effective head design, fabrication and the ability to increase channels, tape speed and linear bit density must be overcome.

Thus, it would be advantageous to provide an improved apparatus, system and method for reading and writing data with enhanced data throughput and positioning control in magnetic media storage applications, such as, for example, in magnetic tape drives.

SUMMARY OF THE INVENTION

The present invention provides a plurality of read/write heads for magnetic media storage applications, such as, for example, a magnetic tape drive. Each head can include a plurality of data channels. In addition to enhancing data throughput, the plurality of read/write heads can be aligned to read or write bands of tracks on a magnetic tape with only one positioning mode (e.g., without coarse position actuation and control), and also obtain optimum yield and crosstalk values.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 depicts a pictorial representation of a conventional read/write head arrangement for a magnetic tape drive that operates with the tape subdivided into bands of tracks;

Figure 2 depicts a pictorial representation of a read/write head assembly for magnetic storage media applications that may be used to implement a preferred embodiment of the present invention;

Figures 3A-3E are related diagrams illustrating various read/write head assemblies for magnetic storage media applications that may be used to implement one or more preferred embodiments of the present invention;

Figures 4A-4C are related diagrams illustrating various read/write head and data channel arrangements for magnetic storage media applications that may be used to implement one or more preferred embodiments of the present invention;

Figures 5A-5B are related diagrams illustrating various read/write head and data channel arrangements for magnetic storage media applications that may be used to

implement a preferred embodiment of the present invention; and

Figure 6 is a block diagram of a tape recording system illustrating an example read/write head assembly that may be used to implement a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures, **Figure 2** depicts a pictorial representation of a read/write head assembly for magnetic storage media applications that may be used to implement a preferred embodiment of the present invention. Referring to the exemplary embodiment shown in **Figure 2**, a pictorial representation of a section **200** of a magnetic tape drive is shown. For clarity, only a pertinent section (**200**) of the magnetic tape drive is shown. In this regard, **Figure 2** is intended only as an example, and not as an architectural limitation for the present invention.

Magnetic tape drive section **200** includes a movable read/write head assembly **202** preferably positioned between tape guides (not shown). For this exemplary embodiment, read/write head assembly **202** includes a plurality of read/write heads **204a-204n**, each of which head can read and write data from and to a magnetic tape **208**. As such, the sub-script "n" can equal 1, 2, 3, ...etc. and represent the total number of read/write heads included in read/write head assembly **202**. For example, if the total number of read/write heads **204a-204n** in read/write assembly **202** is 32 (i.e., "n"=32), then read/write head **204a** can represent a "1st" read/write head, read/write head **204f** can represent a "6th" read/write head, read/write head **204(n-4)** can represent a "28th" read/write head, and so on in read/write head assembly **202**.

Notably, in accordance with a preferred embodiment of the present invention, a plurality of position actuators (e.g., for illustrative purposes only, denoted generally as position actuator **210**) can position the plurality of read/write heads **204a-204n** of read/write head assembly **202** in a vertical direction (as indicated by the vertically oriented arrow in **Figure 2**) so as to align each read/write head **204a-204n** with a corresponding band of a plurality of bands **208a-208n** included on magnetic tape **208**, and thereby read and write data from and to the magnetic media in the respective band. If, as illustrated by this exemplary embodiment, the number of read/write heads **204a-204n** arranged on read/write head assembly **202** equals the number of read/write bands of tracks **208a-208n** arranged on magnetic tape **208**, then the positioning of each read/write head **204a-204n** of read/write head assembly **202** over each corresponding band **208a-208n** included on magnetic tape **208** can be performed successfully with only a fine position actuator (e.g., plurality of actuators **210**) for each read/write head **204a-204n**. In other words, in accordance with the present invention, providing a read/write head for each read/write band on a magnetic tape obviates the conventional need for two positioning modes (both coarse and fine positioning), and also for coarse position actuators.

Also in accordance with a preferred embodiment of the present invention, a single position actuator (e.g., **210**) can be used to position read/write head assembly **202** in a vertical direction (instead of a position actuator

for each read/write head **204a-204n**), which in turn, can align each read/write head **204a-204n** with a corresponding band of a plurality of bands **208a-208n** included on magnetic tape **208** in order to read and write data from and to the magnetic media in the respective band.

Also, for this exemplary embodiment, each read/write head **204a-204n** can be configured to include at least one read/write element **212a** and one write/read element **212b**, as shown in the exploded view **206**. A primary reason for configuring each read/write head **204a-204n** with a read/write element **212a** side-by-side with a write/read element **212b** as shown, is to maintain a sequence of writing and then reading if the tape **208** is moved in either direction.

Data channels are used for transferring data between a read/write head assembly (e.g., **202**) and a magnetic tape drive (e.g., **200**). As described earlier, increasing the number of data channels per read/write head assembly increases the data transfer rate. For this exemplary embodiment, if "M" represents the number of data channels to be used, and "N" represents the number of read/write heads to be provided per head assembly, then "M/N" represents the number of data channels provided per read/write head. For example, if 32 data channels ("M") are to be used for transferring data between read/write head assembly **202** and magnetic tape drive **200**, and 4 read/write heads **204a-204n** ("N") are to be provided, then the number of data channels provided per read/write head ("M/N") is 8. Also, for this embodiment, "N" can

represent the number of read/write bands of tracks **208a-208n** on the magnetic tape.

Referring now to exploded view **206** in **Figure 2**, for this exemplary embodiment, each read/write head **204a-204n** can include at least one pair of read/write and write/read elements (e.g., **212a, 212b**). For illustrative purposes only, the pair of read/write and write/read elements **212a**, **212b** may be associated with at least one data channel (e.g., **214**). However, as demonstrated by the above-described relationship, "M/N", the number of paired read/write and write/read elements e.g., **212a**, **212b)** and data channels (e.g., **214**) provided for each read/write head **204a-204n** can be greater than 2. In this regard, the exploded view **206** in **Figure 2** is intended as an illustrative example, and not as an architectural limitation for the present invention.

Figures 3A-3E are related diagrams illustrating various read/write head assemblies for magnetic storage media applications that may be used to implement one or more preferred embodiments of the present invention. Referring to the exemplary embodiment shown in **Figure 3A**, a pictorial representation of section **300a** of a magnetic tape drive is shown. For this example, section **300a** includes read/write head assembly **302a** and magnetic tape **304**. Magnetic tape **304** includes four bands of tracks **304a-304d**. Similar to the arrangement shown in **Figure 2**, each read/write head of read/write head assembly **302a** can be positioned in a vertical direction, and magnetic tape **304** can be moved in a horizontal direction and in close proximity to read/write head assembly **302a**.

Exemplary read/write head assembly **302a** includes two read/write heads **306** and **308**. Although read/write head assembly **302a** is shown in **Figure 3A** with each read/write head **306**, **308** arranged in a separate assembly structure, the structure and arrangement shown are for illustrative purposes only and not intended as an architectural limitation for the present invention. In other words, read/write head assembly **302a** can be arranged as an integral structure or separate sub-structures. In any event, referring to the channels per head relationship, M/N, described above with respect to **Figure 2**, in order to provide 32 data channels ("M"=32) for transferring data between read/write head assembly **302a** and magnetic tape drive **300a**, each read/write head **306**, **308** ("N"=2) is associated with (and electronically coupled to) 16 data channels.

Referring now to the exemplary embodiment shown in **Figure 3B**, a pictorial representation of a section **300b** of a magnetic tape drive is shown. For this example, section **300b** includes a read/write head assembly **302b** and magnetic tape **304**. Similar to the arrangement shown in **Figure 3A**, magnetic tape **304** includes four bands of tracks **304a-304d**. Also, each read/write head of read/write head assembly **302b** can be positioned in a vertical direction, and magnetic tape **304** can be moved in a horizontal direction and in close proximity to read/write head assembly **302b**.

For this example, read/write head assembly **302b** includes four read/write heads **306-309**. Again, although read/write head assembly **302b** is shown in **Figure 3B** with

each read/write head **306-309** arranged in a separate assembly structure, the structure and arrangement shown are for illustrative purposes only and not intended as an architectural limitation for the present invention. In any event, referring to the channels per head relationship, M/N, described above with respect to **Figure 2**, in order to provide 32 data channels ("M"=32) for transferring data between read/write head assembly **302b** and magnetic tape drive **300b**, each read/write head **306-309** ("N"=4) is associated with (and electronically coupled to) 8 data channels.

Referring now to the exemplary embodiment shown in **Figure 3C**, a pictorial representation of section **300c** of a magnetic tape drive is shown. For this example, section **300c** includes a read/write head assembly **302c** and magnetic tape **304**. Similar to the arrangement shown in **Figure 3A**, magnetic tape **304** also includes four bands of tracks. Also, each read/write head of read/write head assembly **302c** can be positioned in a vertical direction, and magnetic tape **304** can be moved in a horizontal direction and in close proximity to read/write head assembly **302c**.

For this example, read/write head assembly **302c** includes eight read/write heads **306-313**. Again, the structure and arrangement shown for read/write head assembly **302c** are for illustrative purposes only and not intended as an architectural limitation for the present invention. Referring to the above-described channels per head relationship, M/N, in order to provide 32 data channels ("M"=32) for transferring data between

read/write head assembly **302c** and magnetic tape drive **300c**, each read/write head **306-313** ("N"=8) is associated with (and electronically coupled to) 4 data channels.

Referring now to the exemplary embodiment shown in **Figure 3D**, a pictorial representation of section **300d** of a magnetic tape drive is shown. For this example, section **300d** includes a read/write head assembly **302d** and magnetic tape **304**. However, in this embodiment, magnetic tape **304** includes eight bands of tracks **304a-304h**. As such, each read/write head of read/write head assembly **302d** can be positioned in a vertical direction, and magnetic tape **304** can be moved in a horizontal direction and in close proximity to read/write head assembly **302d**.

For this example, read/write head assembly **302d** includes eight read/write heads **316-323**. Again, the structure and arrangement shown for read/write head assembly **302d** are for illustrative purposes only and not intended as an architectural limitation for the present invention. Referring to the above-described channels per head relationship, M/N, in order to provide 32 data channels ("M"=32) for transferring data between read/write head assembly **302d** and magnetic tape drive **300d**, each read/write head **316-323** ("N"=8) is associated with (and electronically coupled to) 4 data channels.

Referring now to the exemplary embodiment shown in **Figure 3E**, a pictorial representation of section **300e** of a magnetic tape drive is shown. For this example, section **300e** includes a read/write head assembly **302e** and magnetic tape **304**. Similar to the exemplary structures shown in **Figures 3A-3C**, magnetic tape **304** includes four

bands (e.g., **304a-304d**). Also, each read/write head of read/write head assembly **302e** can be positioned vertically, and magnetic tape **304** can be moved horizontally and in close proximity to assembly **302e**.

However, for this exemplary embodiment, read/write head assembly **302e** can include any number of read/write heads **306a-306n**. As such, referring to the channels per head relationship, M/N, in order to provide 32 data channels ("M"=32) for transferring data between read/write head assembly **302e** and magnetic tape drive **300e**, each read/write head **306a-306n** (where "N" in this case equals the generalized value of "n") is associated with and electronically coupled to 32/n data channels. Thus, for this exemplary embodiment, if the value of "n" is 32 (e.g., number of read/write heads), then one data channel can be provided for each read/write head **306a-306n**.

Figures 4A-4C are related diagrams illustrating various read/write head and data channel arrangements for magnetic storage media applications that may be used to implement one or more preferred embodiments of the present invention. Referring to the exemplary embodiment shown in **Figure 4A**, a pictorial representation of a section **400a** of a magnetic tape drive is shown. For this example, section **400a** includes a read/write head assembly **402a** and a magnetic tape **404**. Magnetic tape **404** includes four bands of tracks. Similar to the arrangement shown in **Figure 2**, each read/write head of read/write head assembly **402a** can be positioned in a vertical direction, and magnetic tape **404** can be moved in a horizontal

direction and in close proximity to read/write head assembly **402a**.

Exemplary read/write head assembly **402a** includes four read/write heads **406a**, **408a**, **409a** and **410a**. Although read/write head assembly **402a** is shown in **Figure 4A** with four read/write heads **406a**, **408a**, **409a**, **410a** arranged in a particular assembly structure, the structure and arrangement shown are for illustrative purposes only and not intended as an architectural limitation for the present invention.

Referring once again to the channels per head relationship, M/N, described above with respect to **Figure 2**, in order to provide 32 data channels ("M"=32) to transfer data between read/write head assembly **402a** and magnetic tape drive **400a**, each of the four read/write heads **406a**, **408a**, **409a**, **410a** ("N"=4) can be associated with (and electronically coupled to) 8 data channels. As such, in accordance with the present invention, the channels per head relationship, M/N, of 8 channels per head, can be realized with the exemplary configuration of read/write head **408a** of sub-assembly **405a** shown in **Figure 4A**.

As illustrated by the exploded view of read/write head **408a** as an example, each read/write head **406a**, **408a**, **409a**, **410a** can include eight pairs of read/write and write/read elements (e.g., **412a-412h**). Also, each pair of the eight read/write and write/read elements **412a-412h** may be associated with (and coupled to) one data channel. Therefore, for this example, the four read/write heads **406a**, **408a**, **409a**, **410a** can be configured to provide 32

data channels for transferring data between read/write head assembly **402a** and magnetic tape drive **400a**.

Referring now to the exemplary embodiment shown in **Figure 4B**, a pictorial representation of a section **400b** of a magnetic tape drive is shown. For this example, section **400b** includes a read/write head assembly **402b** and a magnetic tape **404**. Magnetic tape **404** includes four bands of tracks.

Exemplary read/write head assembly **402b** includes four read/write heads **406b**, **408b**, **409b** and **410b**. Again, the structure and arrangement shown are for illustrative purposes only and not intended as an architectural limitation for the present invention.

Referring again to the above-described channels per head relationship, M/N, in order to provide 32 data channels ("M"=32) to transfer data between read/write head assembly **402b** and magnetic tape drive **400b**, each of the four read/write heads **406b**, **408b**, **409b**, **410b** ("N"=4) can be associated with (and electronically coupled to) 8 data channels. As such, in accordance with the present invention, the channels per head relationship, M/N, of 8 channels per head, can be realized with the exemplary configuration of read/write head **408b** of sub-assembly **405b** shown in **Figure 4B**.

As illustrated by the exploded view of read/write head **408b** as an example, each read/write head **406b**, **408b**, **409b**, **410b** can include eight read/write/read elements (e.g., **414a-414h**). The read/write/read configuration shown may use separate read and write elements in order to verify that the data was written correctly to the data

storage media. After the data is written, the data is then read for verification. This configuration is referred to as "read-after-write". In any event, each of the eight read/write/read elements **414a-414h** may be associated with (and coupled to) one data channel. Therefore, for this example, the four read/write heads **406b**, **408b**, **409b**, **410b** can be configured to provide 32 data channels for transferring data between read/write head assembly **402b** and magnetic tape drive **400b**.

Referring to the exemplary embodiment shown in **Figure 4C**, a pictorial representation of a variation of the "read-after-write" head arrangement of **Figure 4B** is shown. For this example, section **400c** includes a read/write head assembly **402c** and a magnetic tape **404**. Magnetic tape **404** includes four bands of tracks.

Exemplary read/write head assembly **402c** includes four read/write heads **406c**, **408c**, **409c** and **410c**. Again, the structure and arrangement shown are for illustrative purposes only and not intended as an architectural limitation for the present invention.

Referring again to the above-described channels per head relationship, M/N, in order to provide 32 data channels ("M"=32) to transfer data between read/write head assembly **402c** and magnetic tape drive **400c**, each of the four read/write heads **406c**, **408c**, **409c**, **410c** ("N"=4) can be associated with (and electronically coupled to) 8 data channels. As such, in accordance with the present invention, the channels per head relationship, M/N, of 8 channels per head, can be realized with the exemplary

configuration of read/write head **408c** of sub-assembly **405c** shown in **Figure 4C**.

As illustrated by the exploded view of read/write head **408c** as an example, each read/write head **406c**, **408c**, **409c**, **410c** can include eight write/read/write elements (e.g., **416a-416h**) in a read-after-write arrangement. Each of the eight write/read/write elements **416a-416h** may be associated with (and coupled to) one data channel. Therefore, for this example, the four read/write heads **406c**, **408c**, **409c**, **410c** can be configured to provide 32 data channels for transferring data between read/write head assembly **402c** and magnetic tape drive **400c**.

Figures 5A-5B are related diagrams illustrating various read/write head and data channel arrangements for magnetic storage media applications that may be used to implement a preferred embodiment of the present invention. Referring to the exemplary embodiment shown in **Figure 5A**, a pictorial representation of a section **500a** of a magnetic tape drive is shown. For this example, section **500a** includes a read/write head assembly **502a** and a magnetic tape **504**. In this example, the magnetic tape **504** includes six bands of tracks. Again, similar to the arrangement shown in **Figure 2**, each read/write head of read/write head assembly **502a** can be positioned in a vertical direction, and magnetic tape **504** can be moved in a horizontal direction and in close proximity to read/write head assembly **502a**.

Exemplary read/write head assembly **502a** includes six read/write heads **506a-511a**. Referring to the channels per head relationship, M/N, for this example, in order to

provide 72 data channels ("M"=72) to transfer data between read/write head assembly **502a** and magnetic tape drive **500a**, each of the six read/write heads **506a-511a** (e.g., "N"=6) can be associated with (and electronically coupled to) 12 data channels. As such, in accordance with the present invention, the channels per head relationship, M/N, of 12 channels per head, can be realized with anyone of the exemplary configurations of read/write heads **$508a_1$-$508a_4$** shown in **Figure 5B**.

For example, as illustrated by read/write head **$508a_1$** in **Figure 5B**, each read/write head **506a-511a** can include 12 read and write or write and read elements (e.g., **512a-512f**). Also, each of the 12 read and write or write and read elements **512a-512f** may be associated with (and coupled to) one data channel. Therefore, for this example, the six read/write heads **506a-511a** can be configured to provide 72 data channels for transferring data between read/write head assembly **502a** and magnetic tape drive **500a**.

Similarly, as illustrated by exemplary read/write head **$508a_2$** in **Figure 5B**, each read/write head **506a-511a** can include 12 read and write or write and read elements (e.g., **514a-514f**). Also, for this example, each of the 12 read and write or write and read elements **514a-514f** may be associated with (and coupled to) one data channel. Therefore, for this example, the six read/write heads **506a-511a** can be configured to provide 72 data channels for transferring data between read/write head assembly **502a** and magnetic tape drive **500a**.

Additionally, other read/write head configurations may be used to implement the present invention. For example, each of read/write heads **506a-511a** in **Figure 5A** can include at least one of the read/write head arrangements **508a**$_3$ or **508a**$_4$ in **Figure 5B**. For example, each read/write head **506a-511a** can include 3 sets of read-after-write elements, such as write/read/write sets **516a-516c** of read/write head **508a**$_3$, or read/write/read sets **518a-518c** of read/write head **508a**$_4$. For these examples, each of the 3 sets of write/read/write elements **516a-516c** or read/write/read elements **518a-518c** may be associated with (and coupled to) three data channels. Therefore, for these examples, the six read/write heads **506a-511a** can be configured to provide 54 data channels for transferring data between read/write head assembly **502a** and magnetic tape drive **500a**.

Figure 6 is a block diagram of a tape recording system illustrating an example read/write head assembly that may be used to implement a preferred embodiment of the present invention. For this example, read/write head assembly **600** is arranged in close proximity to a storage media surface of magnetic tape **604**, so that the read/write head assembly **600** can transfer data between magnetic tape **604** and a magnetic tape drive (not shown). As such, exemplary read/write head assembly **600** includes read/write head **602**. As illustrated by this example, read/write head **602** can include a write element **606** and a read element **608**. Write element **606** can be associated with (and electronically connected to) a first data channel for transferring data from the magnetic tape

drive to magnetic tape **604**. Read element **608** can be associated with (and electronically connected to) a second data channel for transferring data from magnetic tape **604** to the magnetic tape drive.

Notably, the exemplary structure, number and arrangement of write and read elements **606**, **608** and data channels are shown in **Figure 6** and described herein for illustrative purposes only and not intended as an architectural limitation for the present invention. For example, read/write head **602** can include any one of the above-described read/write head and channel arrangements shown in **Figures 2-5B**. Also, for example, each write element and read element **606**, **608** in **Figure 6** can be associated with a respective data channel (one data channel for writing, and one data channel for reading). Alternatively, the paired combination of a write element **606** and read element **608** can be associated with one data channel (one data channel for writing/reading).

For clarity, read/write head assembly **600** and magnetic tape **604** are oriented differently in **Figure 6** than in **Figures 2-5B**. For example, a side view of magnetic tape **604** is shown in **Figure 6**, while top surface views of the magnetic tapes in **Figures 2-5B** are shown. Thus, in **Figure 6**, magnetic tape **604** can be depicted as movable in a horizontal direction with respect to read/write head assembly **600**. Similarly, a side view of read/write head assembly **600** is shown in **Figure 6**. However, in this case, read/write head assembly **600** can be depicted as movable in a direction perpendicular to

that of magnetic tape **604** (i.e., into and out of **Figure 6**).

For this exemplary embodiment, write element **606** creates a magnetic field to write or store data on the magnetic media of tape **604**. Data to be written onto magnetic tape **604** is coupled from the magnetic tape drive to an input **610** of a data channel. The input write data is coupled to an encoding unit **612**, which functions primarily to format the input data according to a prescribed protocol for the magnetic storage media involved, perform Error Correction Coding (ECC) to verify the accuracy and validity of the input data received, and encode the valid write data into a prescribed digital sequence. The valid, coded write data can be coupled to a write equalizer unit **614**, which functions primarily to reduce distortion and compensate for attenuation of the coded data signal. The equalized data is then coupled to a write driver unit **616**, which provides electrical current to "drive" or activate the write head element **606**, which, in turn, writes the data onto the storage media of magnetic tape **604**.

Additionally, for this exemplary embodiment, read head element **608** senses or reads data stored in magnetic form on the magnetic media of tape **604**. The data signal is read from magnetic tape **604** in the form of a modulated signal and coupled to a preamplifier and Automatic Gain Control (AGC) unit **618** of a data channel. The current signal generated in read head element **608** by the sensed magnetic data is miniscule, so a primary function of preamplifier and AGC unit **618** is to amplify the sensed

data signal, and control the gain level to compensate for variations in the magnitude of the amplified signal. The amplified read data is coupled to a read equalizer unit **620**, which functions primarily to reduce distortion of the read data signal and compensate for signal attenuation. The equalized read data signal is then coupled to a detector unit **622**, which functions primarily to detect or recover the read data of interest from the signal modulation envelope, carrier or sequence. The detected read data is then coupled to a decoding unit **624**, which functions primarily to decode the read data from the prescribed sequence, perform ECC to verify the accuracy and validity of the decoded read data, and remove the formatting information from the data. The resulting data is coupled to an output **626** of the data channel involved, and to the magnetic tape drive.

Exemplary read/write head assembly **600** also includes track following servo unit **628**, which functions primarily to analyze the magnitude and phase of the read data signal from read head element **608**. The magnitude and phase of the read data signal can be used to determine the vertical alignment of the read head element **608** (and write head element **606**) with respect to a particular track or band on the magnetic storage media of tape **604**. Track following servo unit **628** can use the magnitude and phase of the read data signal in a feedback loop of a servo unit in order to position and align read/write head **602** with respect to the track or band on magnetic tape **604**. A tape guiding and speed control unit **630** can control the movement of the magnetic tape **604**. Notably,

in accordance with the present invention, read/write head assembly **600** can be arranged to provide the above-described data channel per head/track relationship, M/N, which requires only one (fine) read/write head actuation or positioning mode.

The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.